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GSM

**GLOBAL SYSTEM FOR
MOBILE COMMUNICATIONS**

Digital cellular telecommunications system;
Modulation
(GSM 05.04 version 5.1.1 Release 1996)

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Foreword

This European Telecommunication Standard (ETS) has been produced by the Special Mobile Group (SMG) Technical Committee of the European Telecommunications Standards Institute (ETSI).

This ETS specifies the modulation format used within the digital cellular telecommunications system. This ETS corresponds to GSM 05.04 Phase 2 version 4.0.3. This ETS is a GSM technical specification version 5 and is part of the 1996 release of the GSM Technical Specifications.

The specification from which this ETS has been derived was originally based on CEPT documentation, hence the presentation of this ETS may not be entirely in accordance with the ETSI/PNE rules.

Transposition dates	
Date of adoption:	19 May 2000
Date of latest announcement of this ETS (doa):	31 August 2000
Date of latest publication of new National Standard or endorsement of this ETS (dop/e):	28 February 2001
Date of withdrawal of any conflicting National Standard (dow):	28 February 2001

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1 Scope

The modulator receives the bits from the encryption unit, see GSM 05.01 [1], and produces an RF signal. The filtering of the Radio Frequency (RF) signal necessary to obtain the spectral purity is not defined, neither are the tolerances associated with the theoretical filter requirements specified. These are contained in GSM 05.05 [4].

1.1 Normative references

This ETS incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

[1]   GSM 01.04 (ETR 350): "Digital cellular telecommunication system (Phase 2+); Abbreviations and acronyms".

[2]   GSM 05.01: "Digital cellular telecommunication system (Phase 2+); Physical layer on the radio path General description".

[3]   GSM 05.02 (ETS 300 908): "Digital cellular telecommunication system (Phase 2+); Multiplexing and multiple access on the radio path".

[4]   GSM 05.05 (ETS 300 910): "Digital cellular telecommunication system (Phase 2+); Radio transmission and reception".

1.2 Abbreviations

Abbreviations used in this specification are listed in GSM 01.04 [1].

2 Modulation format

2.1 Modulating bit rate

The modulating bit rate is $1/T$ = 1 625/6 kbit/s (i.e. approximately 270,833 kbit/s).

2.2 Start and stop of the burst

Before the first bit of the bursts as defined in GSM 05.02 [3] enters the modulator, the modulator has an internal state as if a modulating bit stream consisting of consecutive ones ($d_i = 1$) had entered the differential encoder. Also after the last bit of the time slot, the modulator has an internal state as if a modulating bit stream consisting of consecutive ones ($d_i = 1$) had continued to enter the differential encoder. These bits are called dummy bits and define the start and the stop of the active and the useful part of the burst as illustrated in figure 1. Nothing is specified about the actual phase of the modulator output signal outside the useful part of the burst.
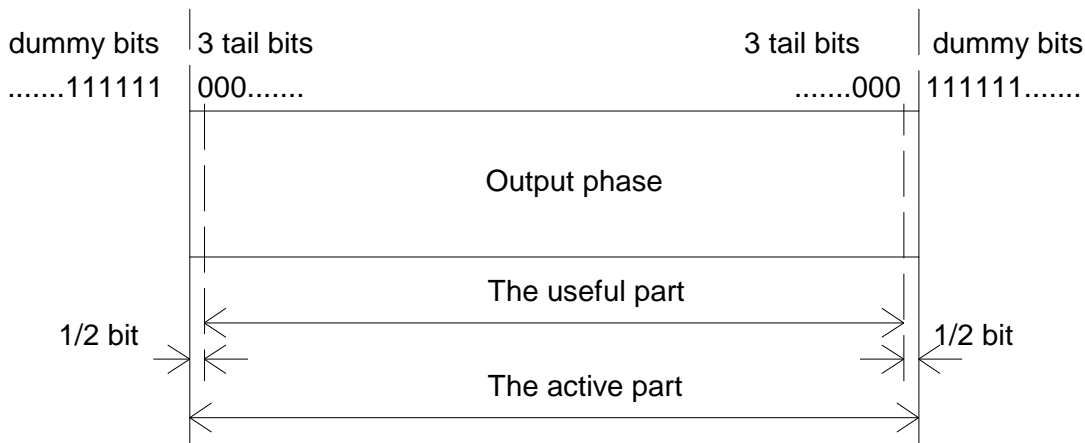
Figure 1: Relation between active part of burst, tail bits and dummy bits. For the normal burst the useful part lasts for 147 modulating bits

2.3   Differential encoding

Each data value $d_i = [0,1]$ is differentially encoded. The output of the differential encoder is:

$$\hat{d}_i = d_i \oplus d_{i-1} \qquad (d_i \in \{0,1\})$$

where $\oplus$ denotes modulo 2 addition.

The modulating data value α_i input to the modulator is:

$$\alpha_i = 1 - 2\hat{d}_i \qquad (\alpha_i \in \{-1, +1\})$$

2.4   Filtering

The modulating data values α_i as represented by Dirac pulses excite a linear filter with impulse response defined by:

$$g(t) = h(t) * rect\left(\frac{t}{T}\right)$$

where the function $rect(x)$ is defined by:

$$rect\left(\frac{t}{T}\right) = \frac{1}{T} \qquad for\ |t| < \frac{T}{2}$$

$$rect\left(\frac{t}{T}\right) = 0 \qquad otherwise$$

and $*$ means convolution. $h(t)$ is defined by:

$$h(t) = \frac{\exp\left(\dfrac{-t^2}{2\delta^2 T^2}\right)}{\sqrt{(2\pi)}\ .\ \delta T}$$

where $\delta = \dfrac{\sqrt{\ln(2)}}{2\pi BT}$ $\qquad and\ BT = 0.3$

where B is the 3 dB bandwidth of the filter with impulse response $h(t)$, and T is the duration of one input data bit. This theoretical filter is associated with tolerances defined in GSM 05.05 [4].

2.5 Output phase

The phase of the modulated signal is:

$$\varphi(t') = \sum_i \alpha_i \pi h \int_{-\infty}^{t'-iT} g(u)du$$

where the modulating index h is 1/2 (maximum phase change in radians is $\pi/2$ per data interval).

The time reference $t' = 0$ is the start of the active part of the burst as shown in figure 1. This is also the start of the bit period of bit number 0 (the first tail bit) as defined in GSM 05.02 [2].

2.6 Modulation

The modulated RF carrier, except for start and stop of the TDMA burst may therefore be expressed as:

$$x(t') = \sqrt{\frac{2E_c}{T}} \cdot \cos(2\pi f_0 t' + \varphi(t') + \varphi_0)$$

where E_c is the energy per modulating bit, f_0 is the centre frequency and φ_0 is a random phase and is constant during one burst.

Annex A (informative):

Change control history

SPEC	SMG	CR	PHA	VERS	NEW_VE	SUBJECT
05.04	s30b	A003	R96	5.0.1	5.1.0	Correction of mistake for range alpha-sub-i in Clause 2.3
05.04				5.1.0	5.1.1	Upgrade of version number to 5.1.1 at Publication

History

Document history			
December 1996	Unified Approval Procedure (First Edition)	UAP 60:	1996-12-02 to 1997-03-28
May 1997	First Edition		
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June 2000	Second Edition		